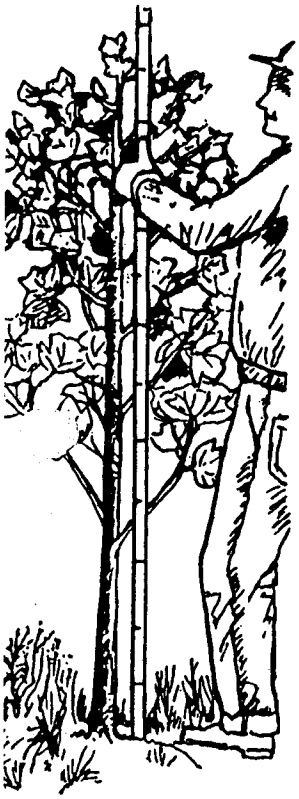

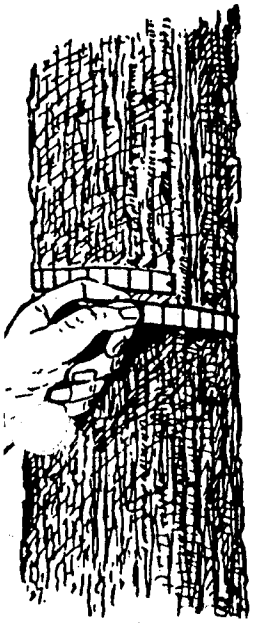

Occasional Report 94 January 1991

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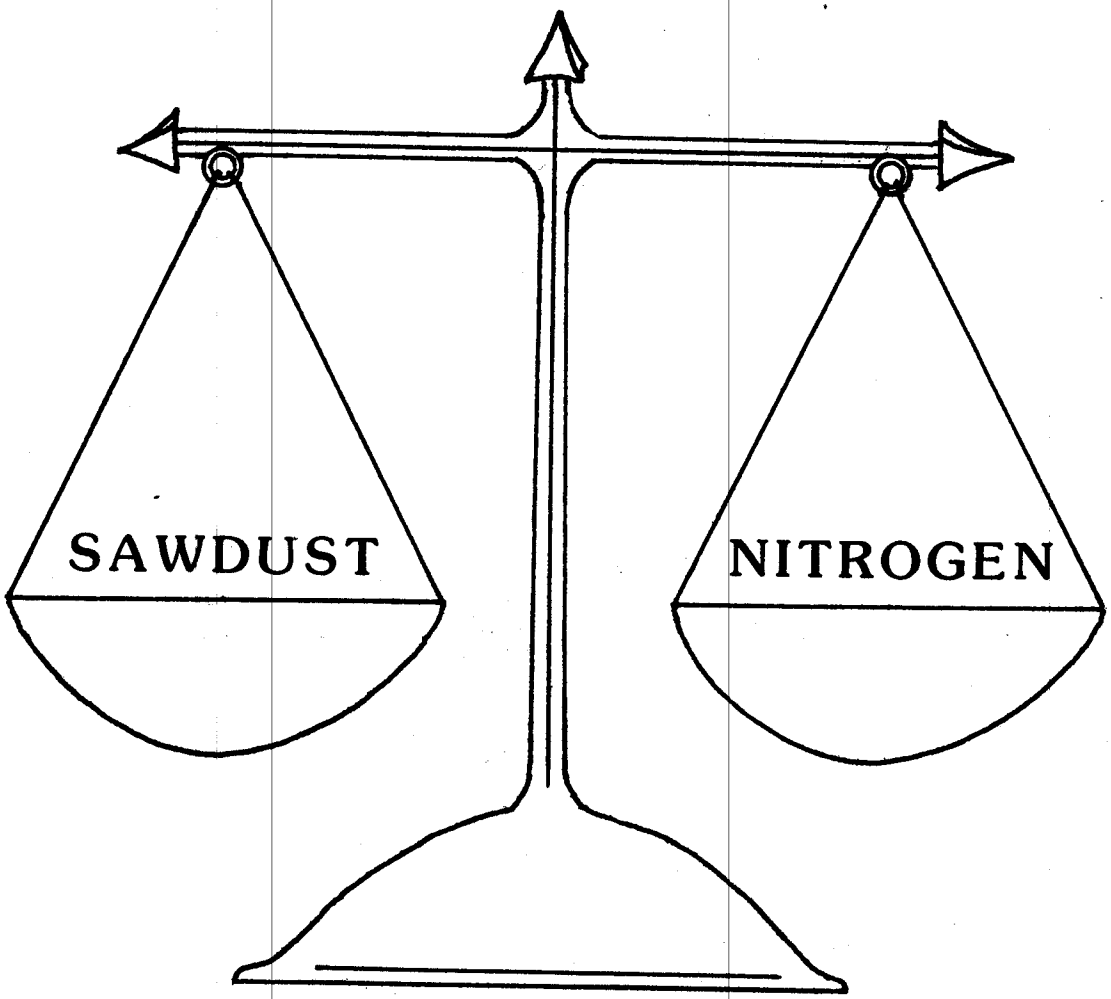

Virginia
Department of Forestry

A FIVE-YEAR STUDY OF DIFFERENT SAWDUST AND NITROGEN RATES IN A LOBLOLLY PINE NURSERY

By: Thomas A. Dierauf

ABSTRACT

Three sawdust rates, 1/2, 1, and 1 1/2 inches, tilled in just before seeding; and two nitrogen rates, operational and twice operational, were tested over a 5-year period. Top-clipping versus no clipping were added as treatments after the second year, and the fifth year also included a 1.5 nitrogen rate.

The heavier sawdust rates tended to reduce growth in the seedbeds slightly, unless supplemented with extra nitrogen. The heavier nitrogen rates tended to increase diameter growth but reduce height growth, especially with the lighter sawdust rates.

In the field, after 3 seasons, there were no consistent effects of either sawdust or nitrogen rates on survival or height, except in the fourth year when the heavy nitrogen rate greatly reduced survival of seedlings stored over winter. Averaging all 5 years, there was a very slight tendency for heavy sawdust rates to reduce third year heights and heavy nitrogen rates to increase them. Top-clipping consistently improved survival and had no effect on third year height.

INTRODUCTION

The Virginia Department of Forestry grows continuous crops of loblolly pine seedlings at its two Coastal Plain nurseries. To maintain soil organic matter, sawdust is incorporated into the seedbed just prior to seeding. Additional nitrogen, beyond the needs of the seedling crop, must be applied to satisfy the needs of the soil organisms that decompose the sawdust. In 1981, a series of five annual studies was initiated at our New Kent nursery to observe the effect of different rates of sawdust and nitrogen on seedling morphology and field performance. The soils at New Kent average better than 90 percent sand.

PROCEDURE

The five studies were similar, consisting of six to nine different combinations of sawdust and nitrogen rates. All five studies employed the same three rates of sawdust. The ½ inch rate was an operational application of approximately ½ inch of sawdust spread with a manure spreader. The 1 inch and 1½ inch rates consisted of the same operational application, plus an additional ½ or 1 inch, respectively, carefully measured by hand. All of the sawdust applied was thoroughly rotavated into the plots just prior to seeding.

There were two nitrogen rates common to all five studies, and a third was included in the last study. The basic two nitrogen rates were that year's operational rate for the nursery as a whole (1N) and twice this rate (2N). In the 1985 study, we added a 1½N rate as well. The actual 1N quantities of elemental nitrogen for each of the studies is given in Table 1.

Table 1. Total operational application of elemental nitrogen (1N) by year.

Year	Pounds of N
1981	270
1982	270
1983	300
1984	250
1985	270

All other cultural treatments were the same as applied to the nursery as a whole. All plots were top-clipped two times in 1981 and 1982, and three times in 1983, 1984, and 1985. However, beginning in 1983, the center half of each treatment plot was left unclipped, so that we could observe the effect of the different sawdust and nitrogen rates on unclipped, as well as clipped, seedlings. We did this because the 2N rate reduced height growth in the 1981 and 1982 studies (except for the heavy sawdust rate in 1982), and the top clipping obscured the magnitude of this reduction by clipping more heavily in the 1N plots.

Treatments were replicated in from four to nine different seedbeds, widely distributed over the nursery. Individual treatment plots were 10 feet long, making each replication 60-90 feet long. Before applying the additional sawdust, we first shaped the bed. Then we laid strips of wood, 10 feet long and either 1/2 or 1 inch thick, along the outside edge of the bed and spread sawdust between them. Then we worked a straight board back and fourth across these guide strips, much as in leveling concrete, to obtain a smooth layer of sawdust of the desired thickness. This was then rotavated into the soil and the beds were reshaped prior to seeding. We relocated the plots again after seeding from pins set along the irrigation lines on both sides of the section. By sighting across these guide pins we could precisely locate the ends of each plot.

For the 1983, 1984, and 1985 studies, in which we left a portion of each plot unclipped, the clipping was done by hand. Shears were run along a guide board of the proper width to give the desired clipping height.

Samples containing 2 square feet, 6 inches wide across the seedbed, were lifted in December. As each 6 inch wide sample was lifted, the seedlings from each of the 8 drill rows were tied separately with twistems. Later, each sample was counted into 4 lots, drill row by drill row. One of the 4 lots was used to randomly select seedlings for planting in the field and the other 3 were saved to measure root collar diameter and top length. Table 2 summarizes the number of samples lifted each year.

Table 2. Numbers of seedbed replications, samples per plot, samples per treatment, and total number of samples by year.

Year	Seedbed Reps	Number of Samples Per Plot	Number of Samples Per Treatment	Total Number of Samples
1981	9	1	9	54
1982	6	2	12	72
1983	5	4*	10	120
1984	4	4*	8	96
1985	4	4*	8	144

* In 1983, 1984, and 1985, half of each treatment plot was top-clipped and half was not. Two samples were lifted from each half.

SEEDBED RESULTS

The 1N rate was not adequate for the heaviest sawdust rates, and the 1N-1½ inch plots were always somewhat chlorotic, and in some years and some seedbed replications, seedling growth, both height and diameter, was noticeably reduced. On the other hand, seedling heights were also reduced by the 2N rate, in all 5 years for the operational ½ inch sawdust rate. Even though height was reduced by the heavy nitrogen rate, diameter growth was usually increased. The effect of the different sawdust and nitrogen rates on average root collar diameter and top length is summarized in Table 3 and Figures 1-10.

FIELD SURVIVAL AND HEIGHT GROWTH

From the many samples lifted to sample root collar diameter and top length, we selected representative samples for planting in the field. Some seedlings were planted in December, soon after lifting, and other seedlings were placed in cold storage for 2 to 3 months and then planted. A 20 seedling row of each treatment was planted in each randomized block, 3 blocks in each year except 1982, when we installed 4 blocks. Seedlings were measured at ages 1, 2, and 3.

None of the sawdust and nitrogen treatments had a consistent effect on field performance, either survival or height growth (Table 4 and Figures 11-20). The 2N rate in 1984 greatly reduced survival of seedlings stored three months, especially unclipped seedlings. Averaging all sawdust and nitrogen treatments for each year, stored seedlings actually survived better in 1982, 1983, and 1985 (Table 4). This is not unexpected in Virginia, where severe winter weather can be more harmful than over-winter storage, for seedlings lifted in December and either planted immediately or stored for 2 or 3 months before planting.

There was a very slight tendency for the 2N rate to increase growth in the field and the heavier sawdust rates to reduce growth. This can be seen in Table 5, where the 5 studies are summarized for seedlings that were top clipped.

Table 3. Average root collar diameter (32nds of an inch), top length (inches), and seedbed density (number per square foot) by treatment and year.

Treatment	1981			1982		
	Dia.	Ht.	No.	Dia.	Ht.	No.
1/2 inch - 1N	4.70	8.1	31.3	4.71	8.8	45.5
2N	4.58	7.6	31.7	4.85	8.3	44.5
1 inch - 1N	4.88	8.6	31.4	4.71	8.4	41.8
2N	4.54	7.4	32.6	4.73	8.4	48.5
1½ inch - 1N	4.92	8.8	36.7	4.34	7.9	47.3
2N	4.60	7.9	38.2	4.74	8.2	43.9

Treatment	Clipped	1983			1984		
		Dia.	Ht.	No.	Dia.	Ht.	No.
1/2 inch - 1N	yes	4.59	7.2	37.3	4.91	7.8	37.4
	no	4.90	9.7	41.0	5.30	10.9	35.8
2N	yes	4.63	6.9	39.7	4.95	7.8	40.8
	no	4.92	8.4	38.9	5.23	10.0	37.5
1 inch - 1N	yes	4.45	6.9	38.5	4.62	7.6	37.8
	no	4.84	9.6	39.7	4.97	10.5	43.7
2N	yes	4.66	6.7	38.8	5.05	7.9	36.6
	no	4.85	8.3	38.4	5.35	10.7	37.2
1½ inch - 1N	yes	4.60	7.1	37.4	4.38	7.5	37.7
	no	4.84	9.4	41.4	4.68	9.4	36.8
2N	yes	4.68	7.0	37.2	5.02	7.8	36.6
	no	4.95	8.9	41.6	5.18	10.1	36.6

Treatment	1985					
	Clipped			Not Clipped		
	Dia.	Ht.	No.	Dia.	Ht.	No.
1/2 inch - 1N	4.32	8.3	54.8	4.59	10.5	54.2
1½N	4.65	8.3	47.7	4.86	10.2	51.0
2N	4.76	8.3	53.0	4.88	9.7	49.5
1 inch - 1N	4.41	8.4	50.3	4.60	10.6	54.3
1½N	4.53	8.4	54.5	4.83	10.1	51.5
2N	4.54	8.1	54.2	4.76	9.6	50.0
1½ inch - 1N	4.16	8.2	54.5	4.54	10.3	54.3
1½N	4.50	8.4	50.1	4.83	10.4	49.5
2N	4.74	8.2	52.3	4.83	10.0	54.7

Figure 1. Root collar diameter at lifting, 1981 study.

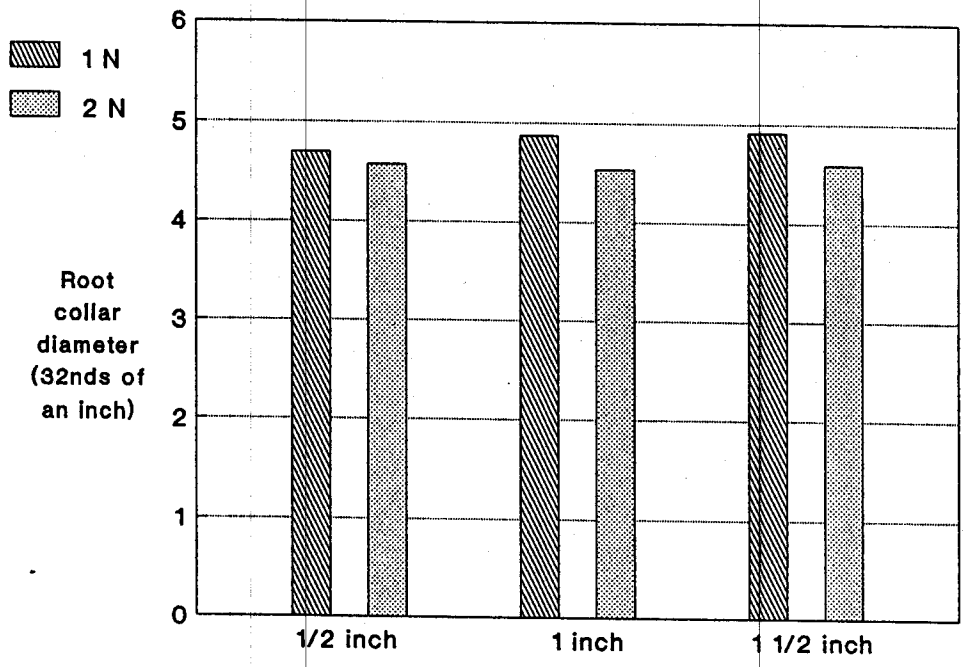

Figure 2. Top length at lifting, 1981 study.

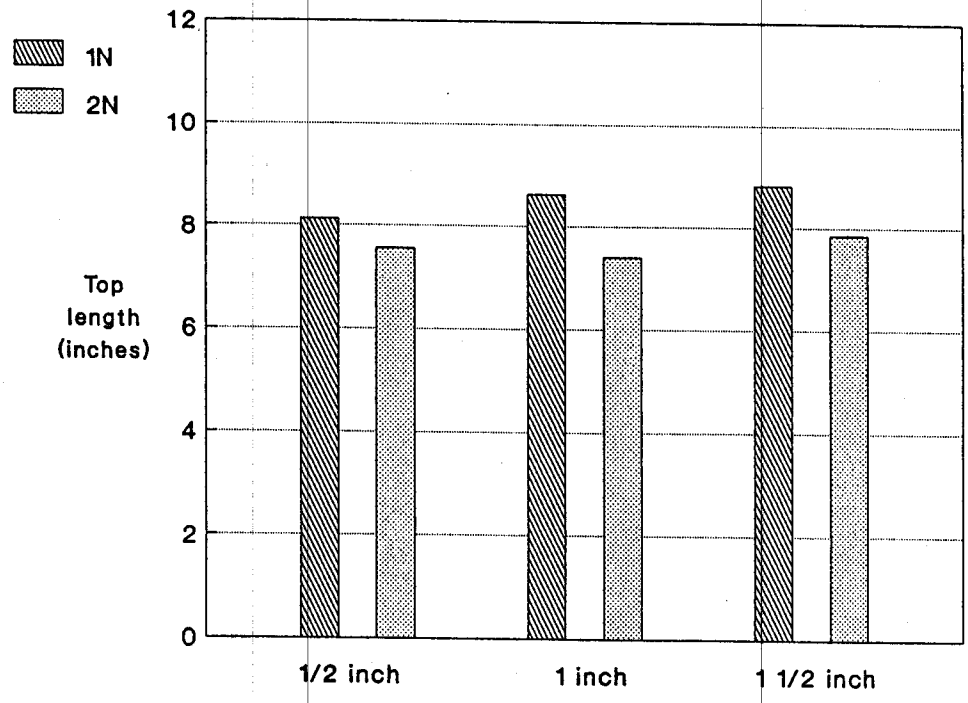

Figure 3. Root collar diameter at lifting, 1982 study.

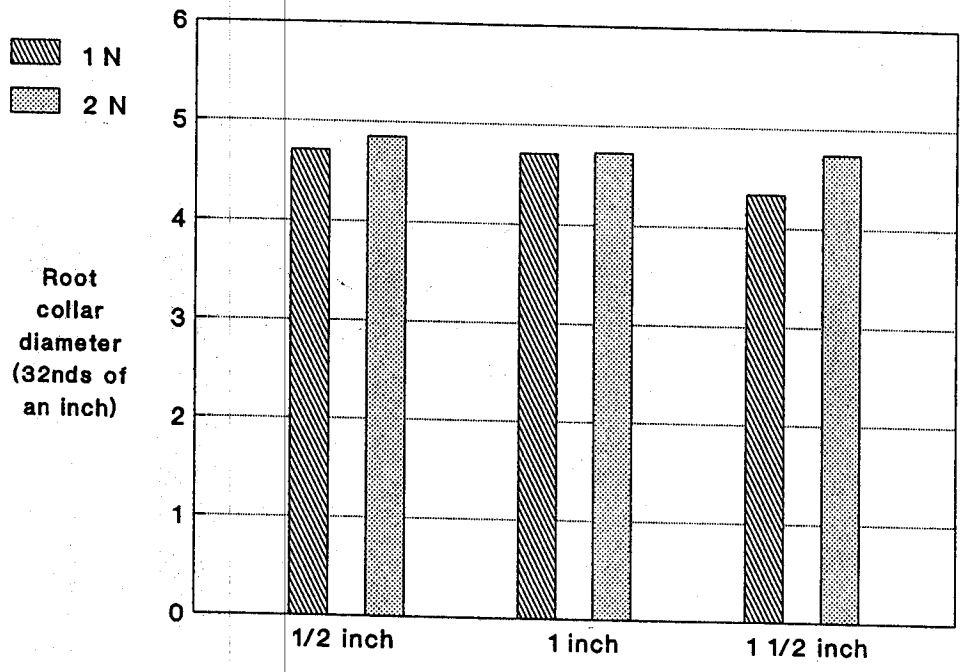

Figure 4. Top length at lifting, 1982 study.

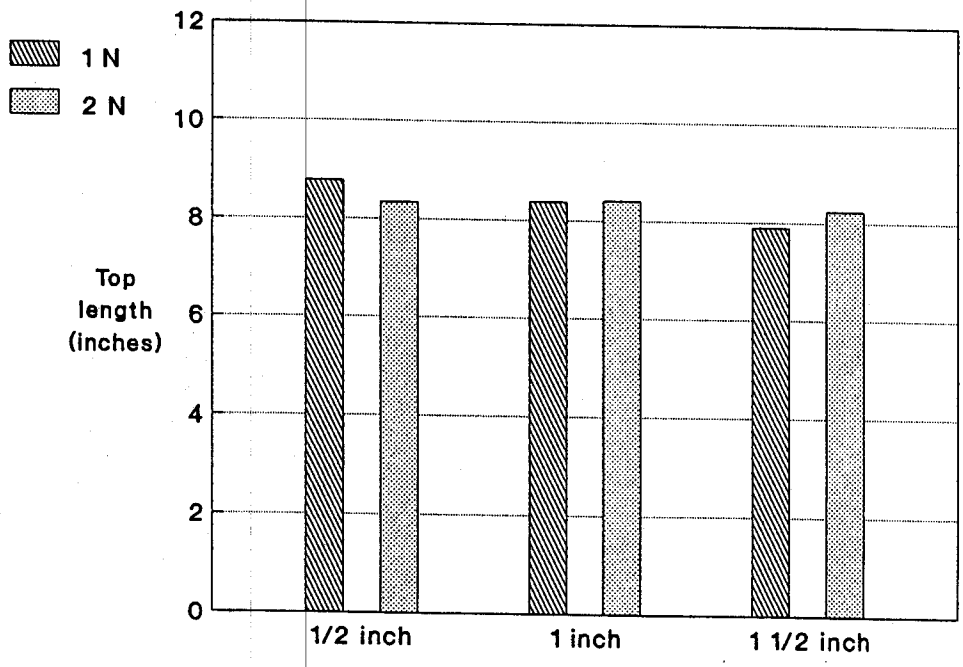

Figure 5. Root collar diameter at lifting, 1983 study.

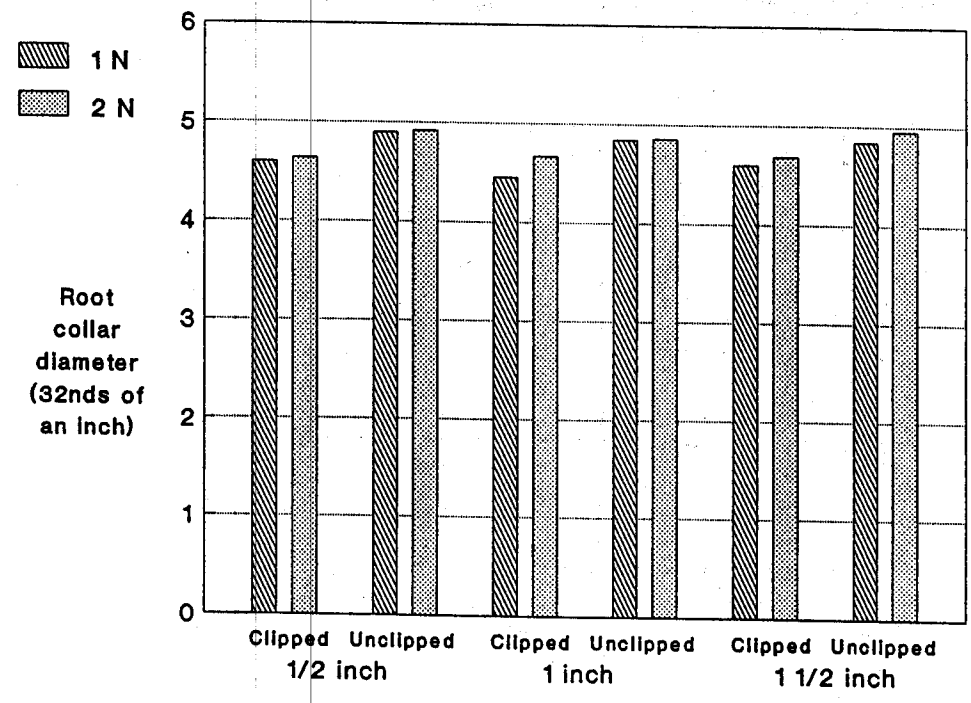

Figure 6. Top length at lifting, 1983 study.

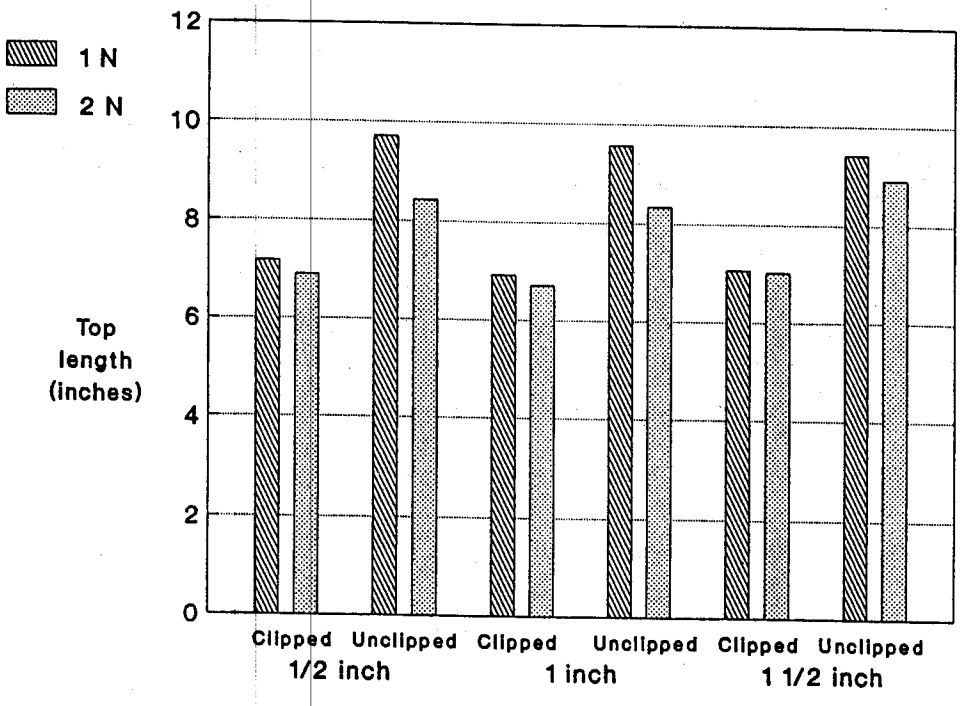

Figure 7. Root collar diameter at lifting, 1984 study.

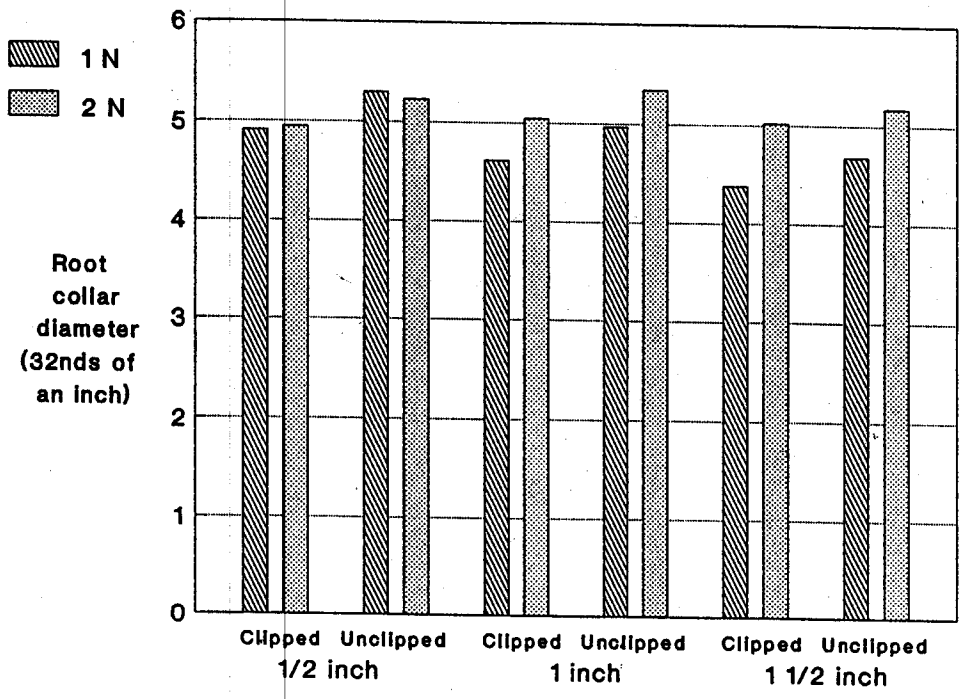

Figure 8. Top length at lifting, 1984 study.

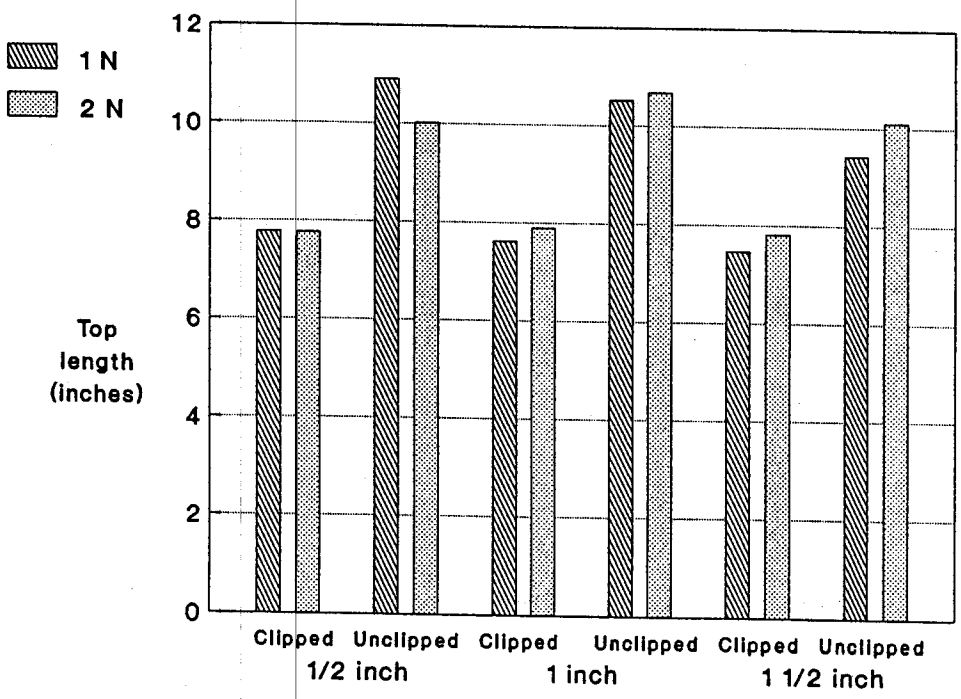

Figure 9. Root collar diameter at lifting, 1985 study.

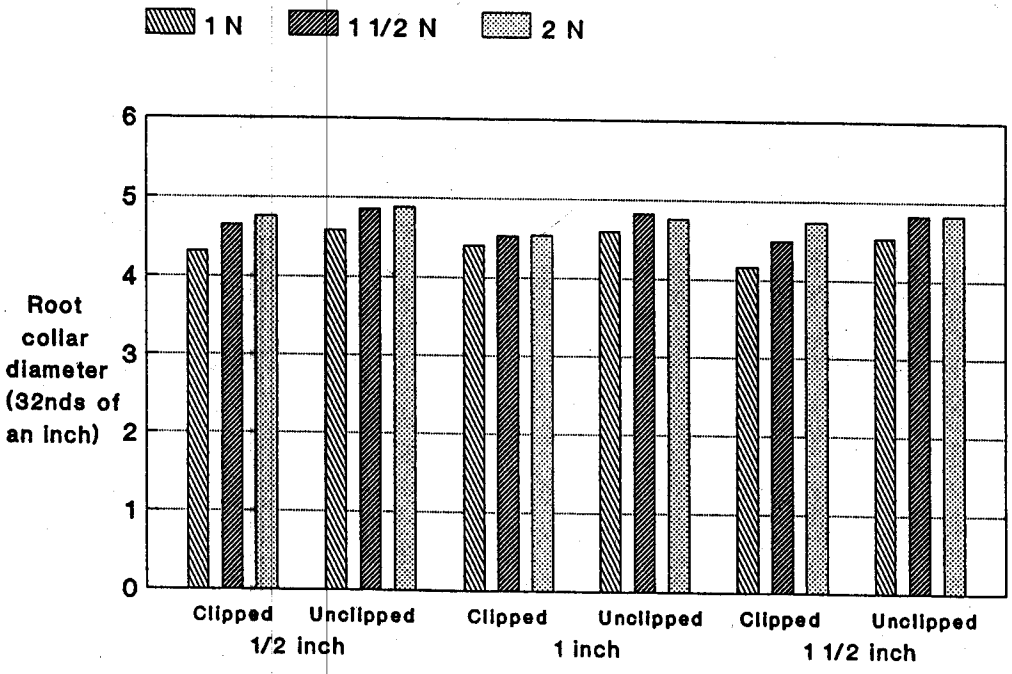

Figure 10. Top length at lifting, 1985 study.

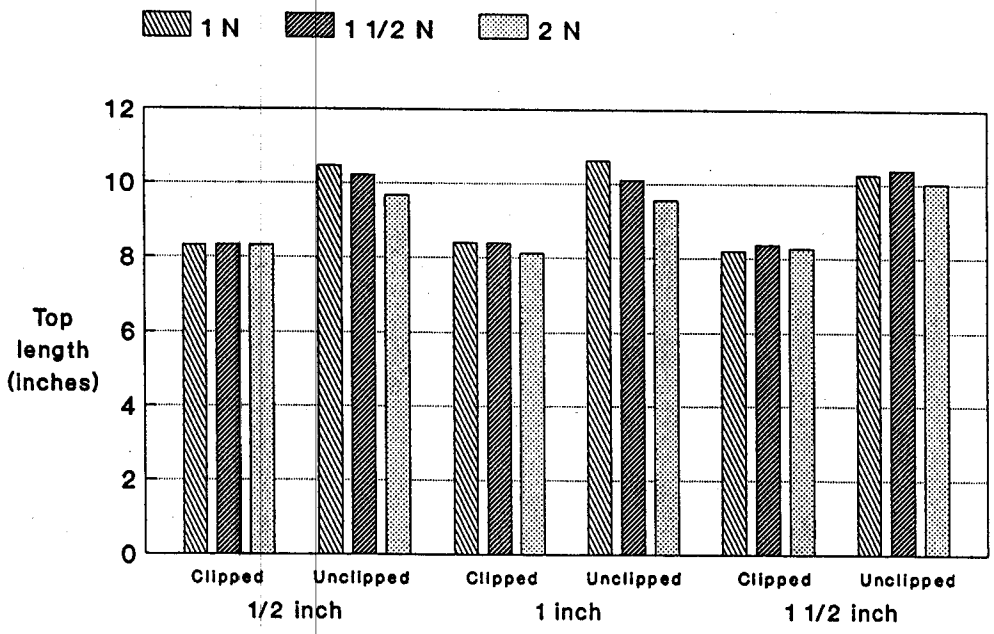

Table 4. Average surivival percent and height (in feet) at age 3, by planting date, treatment, and year.

1981 Study

Treatment	Survival 12/16	Survival 2/25	Survival Means	Height 12/16	Height 2/25	Height Means
½ inch, 1N	88.3	86.7	87.5	5.2	5.3	5.3
2N	90.0	71.7	80.8	5.2	5.2	5.2
1 inch, 1N	95.0	70.0	82.5	5.0	4.8	4.9
2N	91.7	78.0	84.8	5.3	5.2	5.2
1½ inch, 1N	81.7	71.7	76.7	4.9	4.8	4.8
2N	93.3	76.7	85.0	5.0	4.6	4.8
Means	90.0	75.8	82.9	5.1	5.0	5.0

1982 Study

Treatment	Survival 12/21	Survival 3/4	Survival Means	Height 12/21	Height 3/4	Height Means
½ inch, 1N	96.2	92.5	94.4	5.6	6.1	5.8
2N	90.0	98.8	94.4	5.6	5.8	5.7
1 inch, 1N	93.8	93.8	93.8	5.7	5.7	5.7
2N	93.8	88.8	91.2	6.0	5.8	5.9
1½ inch, 1N	91.2	93.8	92.5	5.6	5.9	5.7
2N	95.0	96.2	95.6	5.9	5.7	5.8
Means	93.3	94.0	93.6	5.7	5.8	5.8

1983 Study

Treatment	Survival 12/19 Clipped	Survival 12/19 Not	Survival 3/14 Clipped	Survival 3/14 Not	Survival Means Clipped	Survival Means Not	Height 12/19 Clipped	Height 12/19 Not	Height 3/14 Clipped	Height 3/14 Not	Height Means Clipped	Height Means Not
½ inch, 1N	80.0	61.7	93.3	73.3	86.7	67.5	4.2	4.0	4.6	4.8	4.4	4.4
2N	91.3	73.3	90.0	78.3	90.7	75.8	4.7	3.9	5.2	4.8	4.9	4.3
1 inch, 1N	76.7	51.7	91.7	78.3	84.2	65.0	4.3	4.3	4.5	5.0	4.4	4.6
2N	93.3	78.3	95.0	95.0	94.2	86.7	4.2	4.5	4.4	4.6	4.3	4.6
1½ inch, 1N	73.0	48.3	86.7	88.3	79.8	68.3	3.9	3.6	4.6	4.4	4.2	4.0
2N	68.3	55.0	86.7	85.0	77.5	70.0	4.1	4.6	4.1	4.4	4.1	4.5
Means	80.4	61.4	90.6	83.1	85.5	72.2	4.2	4.2	4.6	4.7	4.4	4.4

Table 4. (continued)

1984 Study

Treatment	Survival 12/13 Clipped	Survival 12/13 Not	Survival 3/14 Clipped	Survival 3/14 Not	Survival Means Clipped	Survival Means Not	Height 12/13 Clipped	Height 12/13 Not	Height 3/14 Clipped	Height 3/14 Not	Height Means Clipped	Height Means Not
½ inch, 1N	91.7	70.0	80.0	63.3	85.8	66.7	5.9	5.6	5.4	5.7	5.7	5.7
2N	88.3	78.3	73.3	30.0	80.8	54.2	6.1	5.5	6.2	4.9	6.2	5.2
1 inch, 1N	91.7	78.3	80.0	65.0	85.8	71.7	5.3	5.6	5.8	5.4	5.6	5.5
2N	85.0	71.7	53.3	31.7	69.2	51.7	5.4	5.8	5.2	5.9	5.3	5.9
1½ inch 1N	88.3	76.7	81.7	50.0	85.0	63.3	5.0	5.3	4.7	5.0	4.9	5.2
2N	90.0	68.3	53.3	36.7	71.7	52.5	6.2	5.9	4.8	5.9	5.5	5.9
Means	89.2	73.9	70.3	46.1	79.7	60.0	5.6	5.6	5.4	5.5	5.5	5.6

1985 Study

Treatment	Survival 12/13 Clipped	Survival 12/13 Not	Survival 3/4 Clipped	Survival 3/4 Not	Survival Means Clipped	Survival Means Not	Height 12/13 Clipped	Height 12/13 Not	Height 3/4 Clipped	Height 3/4 Not	Height Means Clipped	Height Means Not
½ inch, 1N	65.3	56.7	78.3	68.3	71.8	62.5	3.4	3.7	4.0	3.7	3.7	3.7
1½N	80.0	55.0	85.0	61.7	82.5	58.3	4.3	3.7	4.2	3.7	4.2	3.7
2N	66.0	46.7	70.0	50.0	68.0	48.3	4.1	4.2	4.7	4.4	4.4	4.3
1 inch, 1N	73.3	56.7	80.0	60.0	76.7	58.3	4.1	3.2	4.3	3.8	4.2	3.5
1½N	78.3	51.7	83.3	71.7	80.8	61.7	4.3	3.9	4.3	3.6	4.3	3.8
2N	80.0	51.7	75.0	70.0	77.5	60.8	4.1	4.5	4.0	4.4	4.0	4.4
1½ inch, 1N	88.3	56.7	68.3	65.0	78.3	60.8	3.9	4.0	4.0	4.0	3.9	4.0
1½N	80.0	51.0	76.7	66.7	78.3	58.8	4.1	3.8	4.4	3.7	4.3	3.7
2N	76.7	55.0	78.3	51.7	77.5	53.3	3.9.	3.5	4.2	4.0	4.0	3.8
Means	76.4	53.4	77.2	62.8	76.8	58.1	4.0	3.8	4.2	3.9	4.1	3.9

4.1 3.9

Figure 11. Field survival percent at age 3, 1981 study.

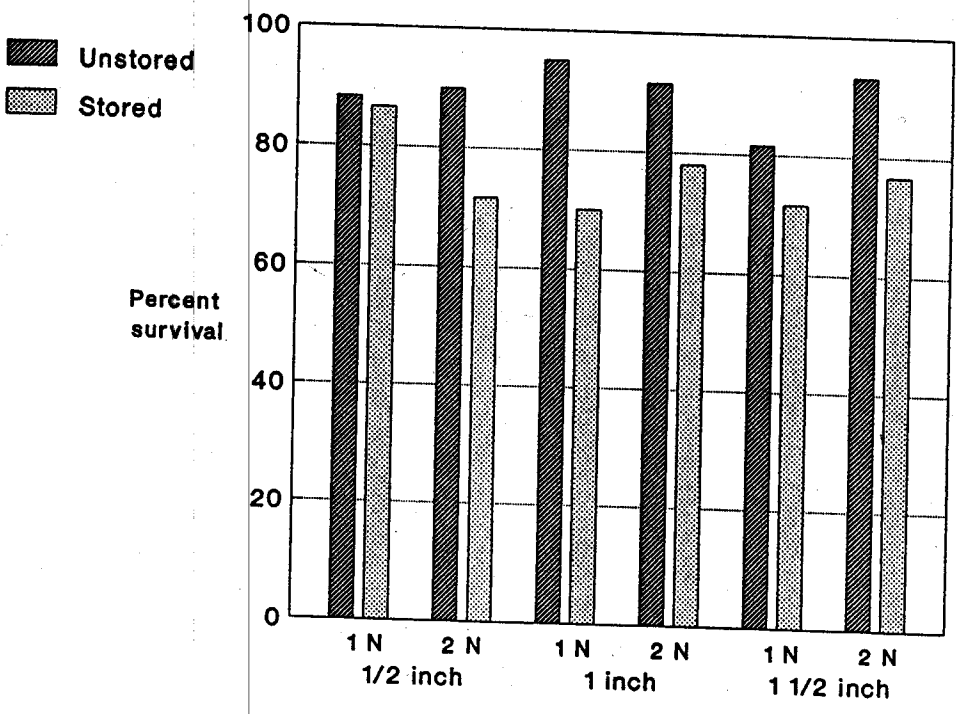

Figure 12. Field survival percent at age 3, 1982 study.

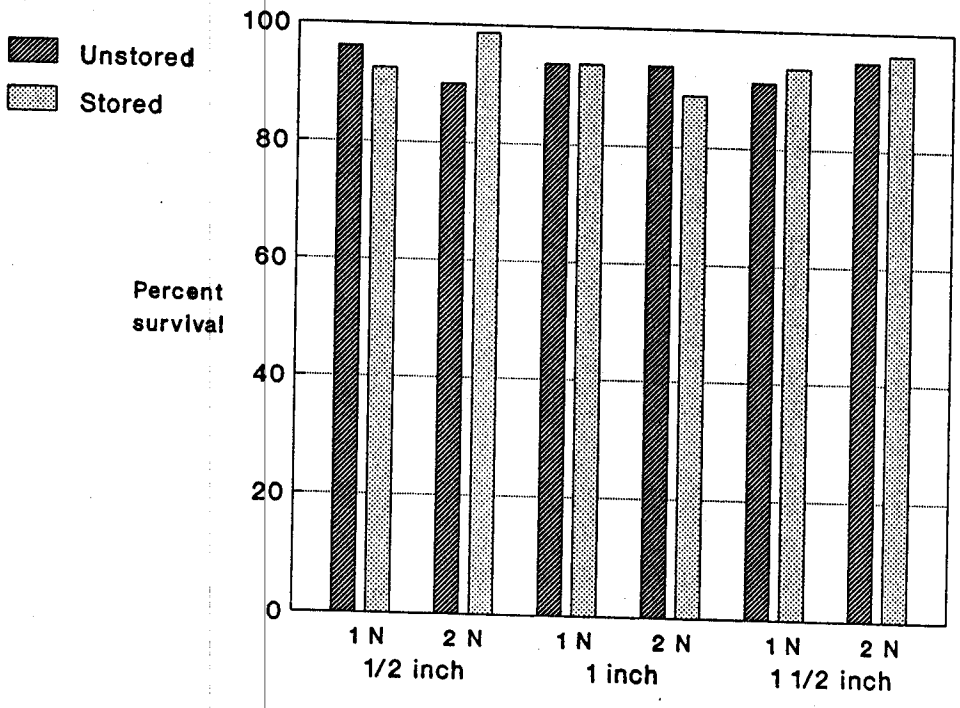

Figure 13. Field survival percent at age 3, 1983 study.

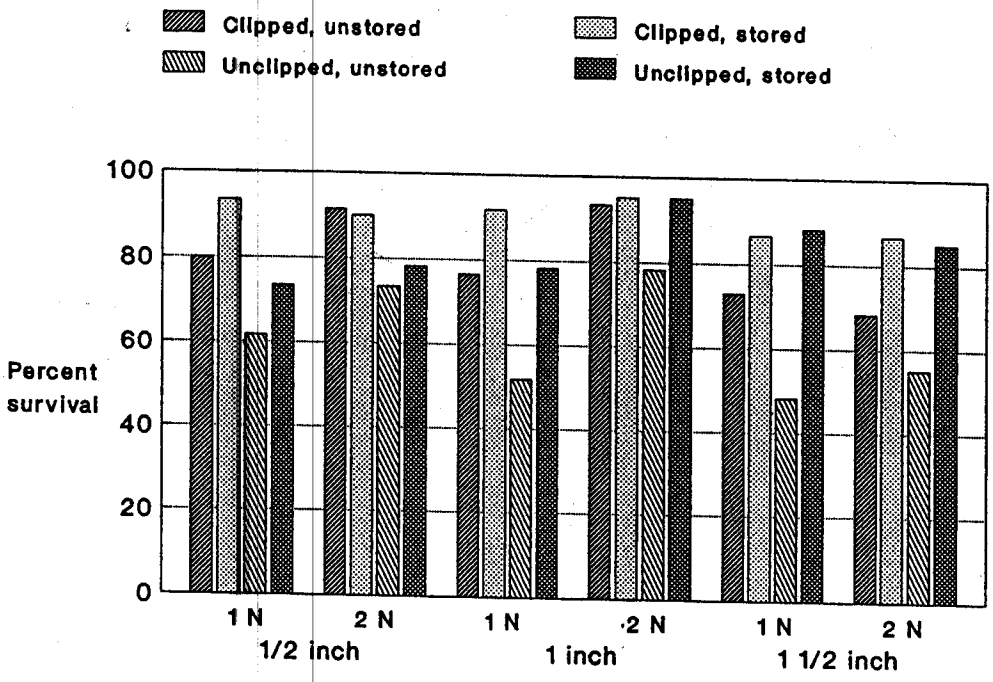

Figure 14. Field survival percent at age 3, 1984 study.

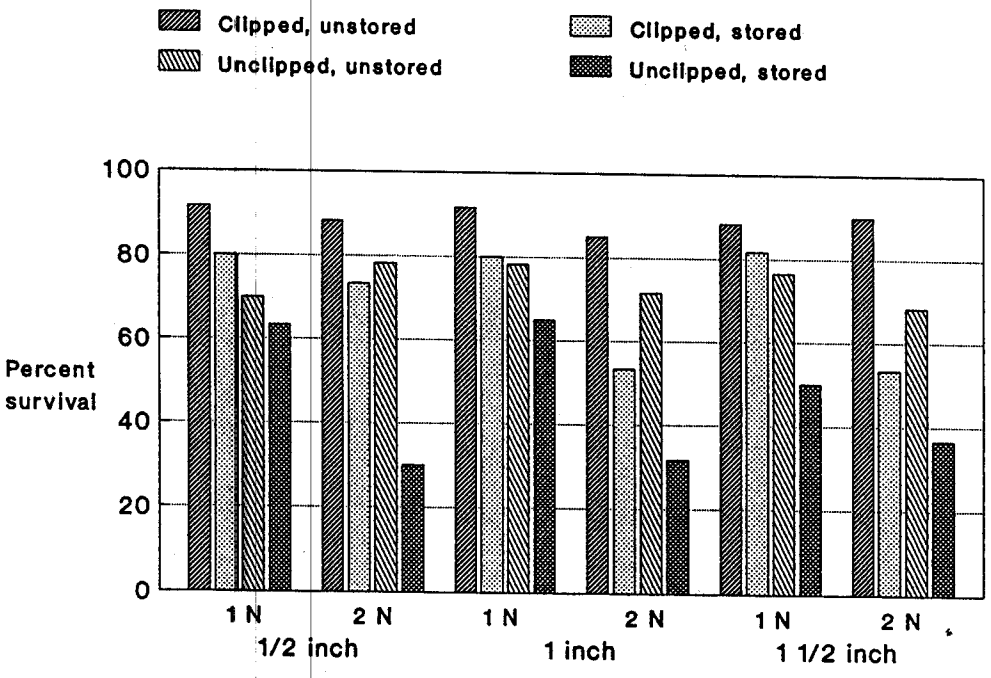

Figure 15. Field survival percent at age 3, 1985 study.

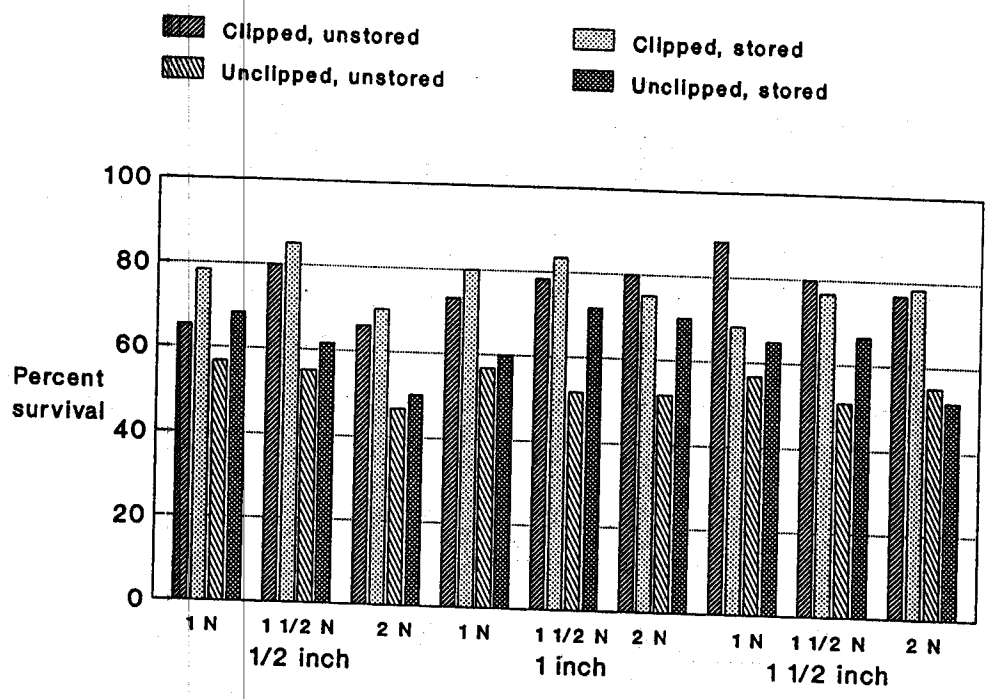

Figure 16. Average field height at age 3, 1981 study.

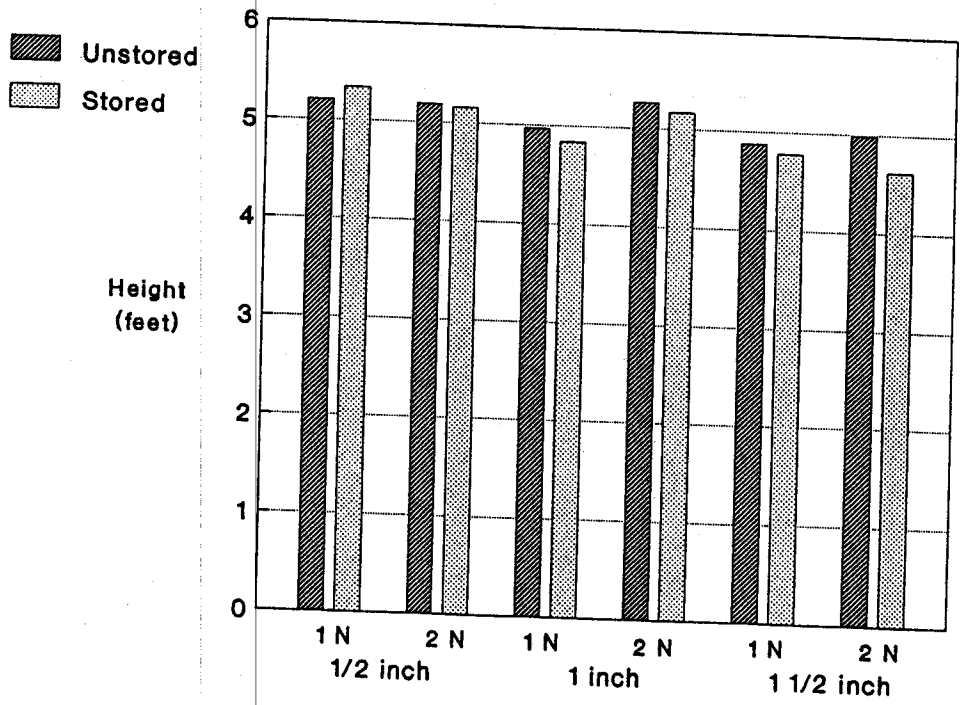

Figure 17. Average field height at age 3, 1982 study.

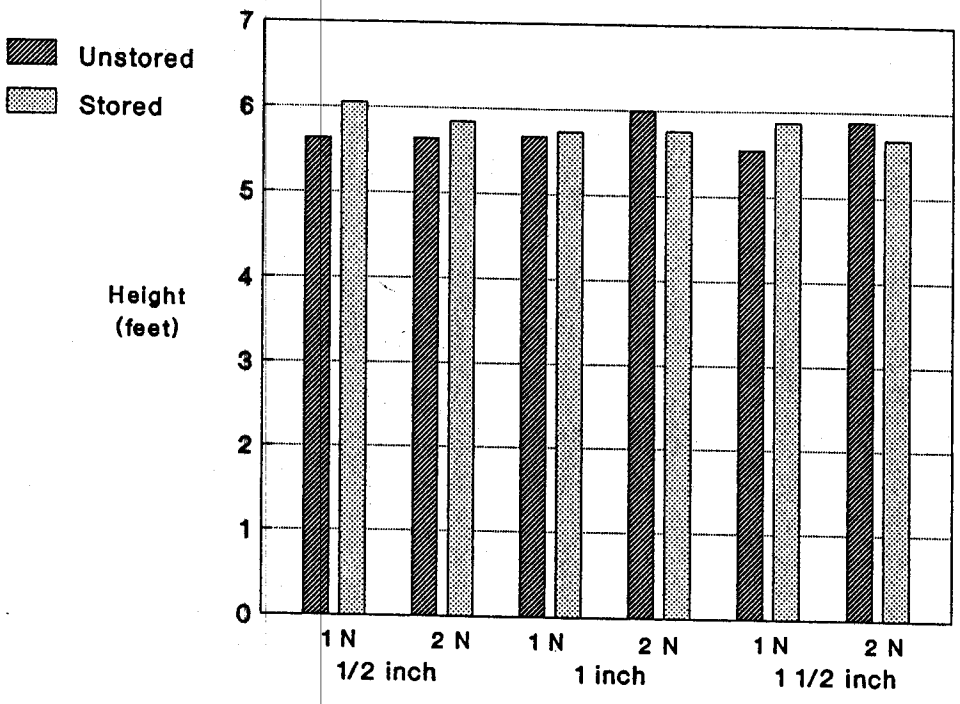

Figure 18. Average field height at age 3, 1983 study.

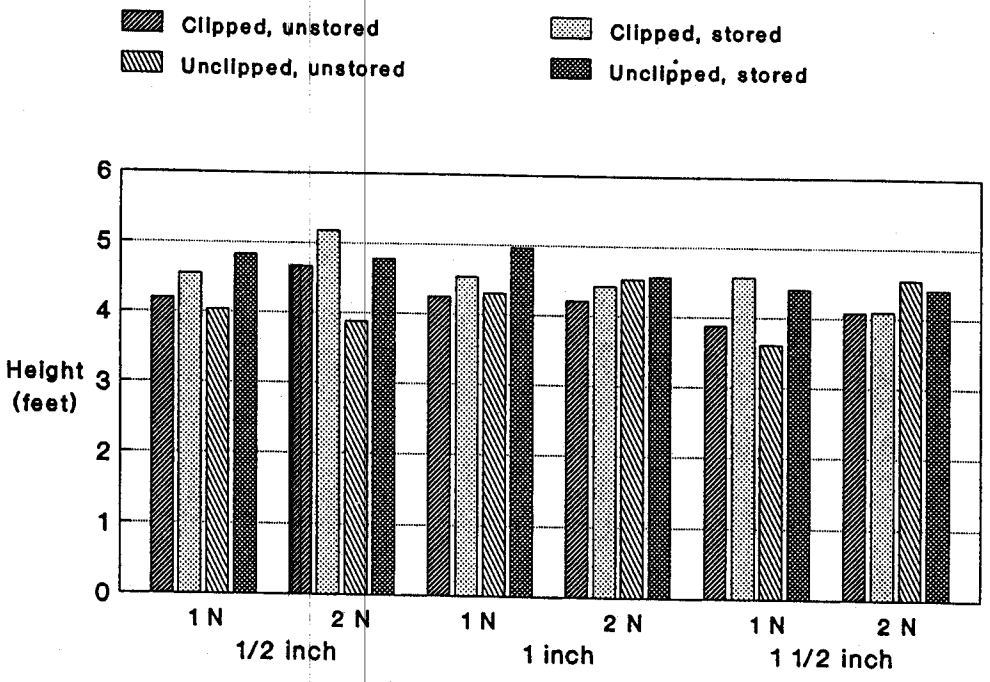

Figure 19. Average field height at age 3, 1984 study.

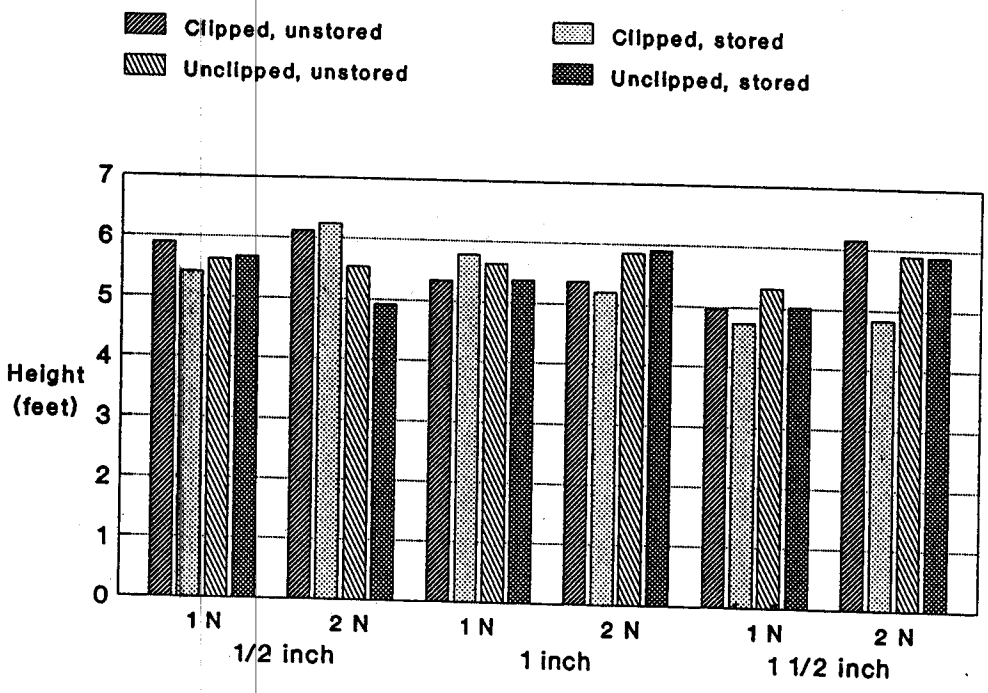

Figure 20. Average field height at age 3, 1985 study.

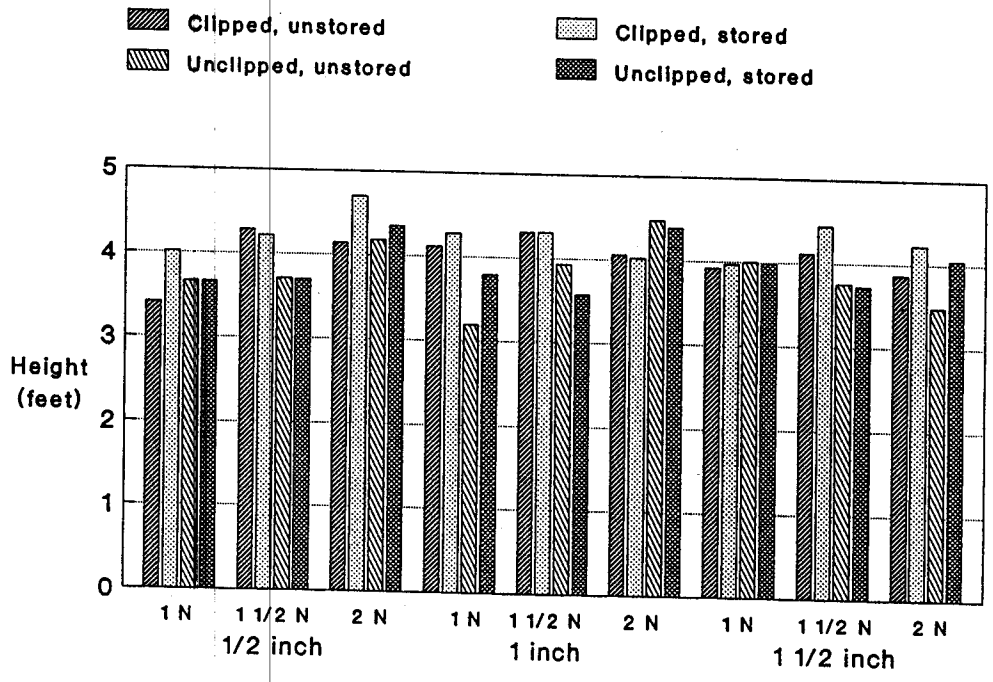

Table 5. Average height at age 3 by sawdust and nitrogen rate, for top-clipped seedlings.

	Clipped and Planted in December											
	1N						2N					
Sawdust	81	82	83	84	85	Means	81	82	83	84	85	Means
½ inch	5.2	5.6	4.2	5.9	3.4	4.9	5.2	5.6	4.7	6.1	4.1	5.1
1 inch	5.0	5.7	4.3	5.3	4.1	4.9	5.3	6.0	4.2	5.4	4.1	5.0
1½ inch	4.9	5.6	3.9	5.0	3.9	4.7	5.0	5.9	4.1	6.2	3.9	5.0

	Clipped and Planted in February or March											
	1N						2N					
Sawdust	81	82	83	84	85	Means	81	82	83	84	85	Means
½ inch	5.3	6.1	4.6	5.4	4.0	5.1	5.2	5.8	5.2	6.2	4.7	5.4
1 inch	4.8	5.7	4.5	5.8	4.3	5.0	5.2	5.8	4.4	5.2	4.0	4.9
1½ inch	4.8	5.9	4.6	4.7	4.0	4.8	4.6	5.7	4.1	4.8	4.2	4.7

Top-clipping, which was added as a treatment in 1983, consistently and significantly improved survival. For our operational sawdust and nitrogen rates (½ inch of sawdust and 1N nitrogen) the improvement was 18.3, 21.7, and 8.6 for December planting in 1983, 1984 and 1985 respectively, and 20.0, 16.7, and 10.0 for seedlings stored until March.

Analyses of variance were performed on the age 3 data, for both survival and height. Survival percents were transformed to arc sine percent. Results of these analyses are presented in Table 6.

CONCLUSIONS

From these studies we have decided that our present sawdust and nitrogen rates (½ inch, 1N) are as good as heavier rates. However, these studies suggest that if we wanted to quickly increase organic matter levels at the same time seedlings are being grown, that sawdust rates of 1 and 1½ inches could be used, as long as additional nitrogen is added.

The heavy nitrogen rates have not helped seedling performance, but they have not hurt either (except for stored seedlings in 1984). We now feel much safer about making an extra application of nitrogen if we see chlorosis developing. Our rule is "if in doubt, put on more nitrogen".

Table 6. Analyses of variance for age 3 measurements.

1981 Study

Source	d.f.	Survival MS	Survival F	Survival Prob.	Height MS	Height F	Height Prob.
Treatments	11	180.48	2.93	.015	.1474	.72	.70
Sawdust (Sw)	2	48.25	.78	.47	.5001	2.46	.11
Nitrogen (N)	1	38.30	.62	.44	.0355	.17	.68
Storage (St)	1	1,383.47	22.44	.0001	.0890	.44	.52
Sw x N	2	78.55	1.27	.30	.1493	.73	.49
Sw x St	2	48.86	.79	.47	.0616	.30	.74
N x St	1	55.13	.89	.35	.0406	.20	.66
Sw x N x St	2	78.52	1.27	.30	.0172	.08	.92
Reps	2	117.28	1.90	.17	.1565	.77	.48
Error	22	61.64			.2036		

1982 Study

Source	d.f.	Survival MS	Survival F	Survival Prob.	Height MS	Height F	Height Prob.
Treatments	11	60.88	.83	.61	.098	1.16	.35
Sawdust	2	36.43	.50	.61	.011	.13	.88
Nitrogen	1	33.97	.46	.50	.025	.29	.59
Storage	1	3.88	.05	.82	.109	1.29	.26
Sw x N	2	40.04	.55	.58	.081	.95	.40
Sw x St	2	49.00	.67	.52	.169	1.99	.15
N x St	1	38.48	.53	.47	.369	4.35	.04
Sw x N x St	2	171.20	2.34	.11	.027	.32	.73
Reps	3	392.94	5.37	.004	2.329	27.41	.000000004
Error	33	73.15			.085		

Table 6. (continued)

1983 Study

Source	d.f.	Survival MS	Survival F	Survival Prob.	Height MS	Height F	Height Prob.
Treatments	23	330.5	3.30	.0003	.40	1.75	.05
Sawdust	2	256.4	2.56	.09	.71	3.11	.06
Nitrogen	1	525.6	5.25	.03	.18	.79	.38
Clipping (C)	1	1,512.8	15.11	.0003	.00	.00	1.00
Storage	1	2,680.2	26.77	.000005	3.24	14.21	.0005
Sw X N	2	308.1	3.08	.06	.16	.68	.50
Sw X C	2	143.3	1.43	.25	.40	1.75	.19
Sw X St	2	257.1	2.57	.09	.20	.90	.43
N X C	1	66.9	.67	.42	.00	.00	1.00
N X St	1	152.2	1.52	.22	.51	2.24	.14
C X St	1	329.0	3.29	.08	.13	.57	.46
3 way + 4 way	9	45.1	.45	.90	.24	1.06	.42
Reps	2	54.4	.54	.58	5.72	25.10	$5x10^{-8}$
Error	46	100.1			.23		

1984 Study

Source	d.f.	Survival MS	Survival F	Survival Prob.	Height MS	Height F	Height Prob.
Treatments	23	450.1	7.21	$8x10^{-9}$	.56	2.55	.004
Sawdust	2	23.5	.38	.69	.66	3.00	.06
Nitrogen	1	1,330.9	21.32	.00003	1.21	5.50	.02
Clipping	1	3,282.2	52.58	$4x10^{-9}$	.05	.23	.64
Storage	1	4,364.4	69.92	$9x10^{-11}$	.95	4.32	.04
Sw x N	2	57.2	.92	.41	.78	3.55	.04
Sw x C	2	39.8	.64	.53	1.26	5.73	.006
Sw x St	2	17.7	.28	.75	.35	1.59	.21
N x C	1	.1	.00	.96	.01	.05	.83
N x St	1	663.7	10.63	.002	.16	.73	.40
C x St	1	33.8	.54	.47	.04	.18	.67
3 way + 4 way	9	44.5	.71	.69	.49	2.23	.04
Reps	2	5.2	.08	.92	1.32	6.00	.005
Error	46	62.4			.22		

1985 Study

Source	d.f.	Survival MS	Survival F	Survival Prob.	Height MS	Height F	Height Prob.
Treatments	35	168.2	2.88	.00008	.321	1.13	.33
Sawdust	2	68.2	1.17	.32	.052	.18	.83
Nitrogen	2	124.0	2.13	.13	.978	3.43	.04
Clipping	1	3,894.1	66.76	$9x10^{-12}$	1.893	6.64	.01
Storage	1	233.0	3.99	.05	.641	2.25	.14
Sw x N	4	54.1	.93	.45	.401	1.41	.24
Sw x C	2	9.1	.16	.86	.004	.01	.99
Sw x St	2	80.9	1.39	.26	.078	.27	.76
N x C	2	25.9	.44	.64	.623	2.18	.12
N x St	2	30.5	.52	.59	.214	.75	.48
C x St	1	189.8	3.25	.08	.100	.35	.56
3 way + 4 way	16	42.4	.73	.76	.194	.68	.80
Reps	2	109.6	1.88	.16	1.473	5.16	.008
Error	70	58.3			.285		